Appendix C

Fish Abundance and Diversity Assessment

Prepared by
James H. McKenna, Ph.D.

Public Access to Shoreline Recreational Fishing in Narragansett Bay

Evaluation of Alternative Sites for Fishing Access

Appendix C:
Fish Abundance and Diversity Assessment

Submitted by:

James H. McKenna, Ph.D.

11 Cedar Lane
Mount Desert, ME
voice: 207-244-7401
fax: 207-244-7401
jim.mckenna@snet.net

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Introduction:

To assess the quality of recreational fishing opportunities at the alternative fishing access sites, patterns of fish abundance and diversity in Narragansett Bay, Mt. Hope Bay, and the Sakonnet River were evaluated through analysis of Rhode Island Department of Environmental Management (RIDEM) monthly fish trawl survey data. Qualitative assessments of fishing quality were also made using data collected from the RIDEM *2005 online recreational fishing survey* and additional anecdotal information.

Analysis:

RIDEM fish trawl data evaluated in this report were from twelve stations (Figure 1) located throughout Narragansett Bay, Mt Hope Bay and the Sakonnet River (these regions are collectively referred to as 'the bay' throughout the remainder of this report). Data were collected over a 15 year period from 1990 to 2004. Fish abundance estimates for the old Jamestown Bridge (JB) site, described in a previous report (see *Public Access to Shoreline Recreational Fishing in Narragansett Bay: Evaluation of the Old Jamestown Bridge Site*. RIDEM, 2005) were also included in the current report. All fish abundance data were averaged, interpreted, and presented as mean numbers of fish per tow.

While the trawl survey is an excellent quantitative data set, limitations in the gear and methods employed for the trawl likely lead to undersampling of several important recreational fish species thus resulting in low abundance estimates. For example, pelagic predatory fish such as bluefish, striped bass, and weakfish are likely underrepresented in the trawl data because these species are too large, and swim too quickly to be captured efficiently by the gear employed in the RIDEM trawl survey. Additionally, due to the tendency of these fish to congregate in dense feeding schools, the concentration of these species is typically highly mobile and patchy. Generalized estimates of regional abundances are therefore difficult to estimate for these species. Tautog and black sea bass may also be underrepresented in trawl survey data because these species tend to be attracted to hard substrates, such as rocks and man-made structures like piers and pilings. By necessity, trawling is conducted in flat, open areas with little hard substrate which would tend to snag a net. Shoreline structures offering fishing access will often provide hard substrates which would possibly concentrate species such as tautog and black sea bass.

Furthermore, geographic differences between the alternative access sites and the trawl stations limit the data's usefulness for predicting the types of fish likely to be found at specific alternative access locations. Therefore, bay-wide spatial and temporal patterns in fish abundance and species richness (number of different species) were evaluated and generalized conclusions drawn about conditions in three geographic regions: lower bay, mid bay, and upper bay. Alternative access sites were then assigned to a corresponding geographic region to assess potential recreational fishing quality (Table 1). Alternative access sites in the Seekonk River, Providence River, and Greenwich Bay were not assigned to one of the three geographic regions as these locations were considered oceanographically distinct and unrepresented by available trawl data. Despite these methodological and geographical limitations, the trawl data is still a useful tool for qualitatively comparing and contrasting distributions of finfish throughout the bay, and hence in

determining likely regions of the bay which would support quality recreationally fishing opportunities.

Table 1. Geographic regions for trawl station data and alternative pier site assignments.

Category	Trawl stations defining region	Alternative site assignment	
Lower Bay	197, 194, JB site	8) Sakonnet Point 12) Brenton Point 13) Van Zandt Pier 14) Fort Adams	15) Fort Getty 16) Hull Cove 17) Fort Wetherill 22) Bay Campus
Mid Bay	158, 132, 138, 89, 52	9) Stone Bridge 10) Carr Point 11) Burma Road	18) Rome Point 19) QPD Allen's Harbor
Upper Bay	25, 13.2, 13.1, 26, 2	4) Palmer River Bridge 5) Colt State Park	6) Bristol Narrows 7) Bristol Ferry Landing
Unassigned	No appropriate trawl stations	1) State Pier #2 2) Gano Street 3) Sabin Point	20) Salter Grove 21) Goddard Park

Total fish abundances were compared across the trawl stations and JB site to assess geographic variations within the bay. Trawl data were averaged over the 15 year period and plotted by station (figure 2). In this, and all subsequent analyses, stations were arranged geographically from south to north to correspond to a generalized bay transect and grouped into 'lower', 'mid', and 'upper' bay stations as indicated in table 1. No distinction was made between west passage, east passage, the Sakonnet River, or Mt Hope Bay; rather these were all grouped together as 'bay' stations. For reference and comparison, data interpreted for the JB site were also plotted and considered part of the lower bay.

Total fish abundance data indicated a distinct maximum in mid bay regions: stations 138 (Sakonnet), 89 (west passage), and 158 (east passage) displayed the three highest abundances (2372, 1663, and 1331 fish/tow, respectively). Station 52 (Sakonnet), although technically a mid bay station, did display the lowest overall abundance (348 fish/tow). This seeming discrepancy may be explained by considering the specific physiographic environment at station 52. While station 52 geographically corresponds to a mid-bay station, because of its shallowness, bottom type, and tendency to accumulate large masses of algae, it is physiographically much more similar to upper bay stations (Tim Lynch, RIDEM, personal communication). Upper bay stations generally showed lower abundances (all were < 750 fish/tow). The physiographic nature of station 52, and its similarity to upper bay stations, would thus be consistent with the low abundance found at this station. Lower bay stations displayed intermediate abundances (925-1004 fish/tow) and were very similar to estimates for the Jamestown Bridge site (924 fish/tow).

Total fish abundance data were subdivided into important recreational fish species, clupeiform species, and all other species to assess abundance variations of some significant species groups (see table 2 for species represented in each group). All three of these groups displayed the same general trend as all species combined: greatest values in mid bay, intermediate values in the lower bay, and lesser abundances in the upper bay. The clupeiform species group did display the

greatest variation (maximum of 1551 fish/tow at station 138; minimum of 140 at station 52) and was largely accountable for the high abundance numbers associated with both stations 138 and 89. The clupeiform data also showed less variation between upper and lower bay, suggesting that clupeiforms, an important food source for migratory predators such as bluefish and striped bass, are more evenly distributed throughout the bay.

Table 2. Fish species list and group assignments.
Common and scientific names and group assignments of Narragansett Bay species included in graphs and text discussions. "Important" group includes recreational species considered important in Narragansett Bay according to RIDEM (Tim Lynch, personal communication). Pleuronectiform includes flatfish species belonging to the Order *Pleuronectiformes*. Clupeiform includes herring-like species belonging to the Order *Clupeiformes* and *Atheriniformes.* Gadiform includes cod-like species belonging to the Order *Gadiformes*.

Common Name	Scientific Name	Group
Bluefish	*Pomatomus saltatrix*	Important
Striped Bass	*Morone saxatilis*	Important
Black Sea Bass	*Centropristis striata*	Important
Scup	*Stenotomus chrysops*	Important
Weakfish	*Cynoscion regalis*	Important
Tautog	*Tautoga onitis*	Important
Longfin Squid	*Loligo pealeii*	Important
Summer Flounder	*Paralichthys dentatus*	Important, Pleuronectiform
Winter Flounder	*Pseudopleuronectes americanus*	Important, Pleuronectiform
Fourspot Flounder	*Hippoglossina oblonga*	Pleuronectiform
Yellowtail Flounder	*Limanda ferruginea*	Pleuronectiform
Winter Flounder	*Pseudopleuronectes americanus*	Pleuronectiform
Windowpane	*Scophthalmus aquosus*	Pleuronectiform
Gulfstream Flounder	*Citharichthys arctifrons*	Pleuronectiform
Atlantic Silverside	*Menidia menidia*	Clupeiform
Round Herring	*Etrumeus teres*	Clupeiform
Atlantic Herring	*Clupea harengus harengus*	Clupeiform
Alewife	*Alosa pseudoharengus*	Clupeiform
Blueback Herring	*Alosa aestivalis*	Clupeiform
American Shad	*Alosa sapidissima*	Clupeiform
Atlantic Menhaden	*Brevoortia tyrannus*	Clupeiform
Hickory Shad	*Alosa mediocris*	Clupeiform
Bay Anchovy	*Anchoa mitchilli*	Clupeiform
Striped Anchovy	*Anchoa hepsetus*	Clupeiform
Silver Hake	*Merluccius bilinearis*	Gadiform
Atlantic Cod	*Gadus morhua*	Gadiform
Haddock	*Melanogrammus aeglefinus*	Gadiform
Pollock	*Pollachius virens*	Gadiform
White Hake	*Urophycis tenuis*	Gadiform
Red Hake	*Urophycis chuss*	Gadiform
Spotted Hake	*Urophycis regia*	Gadiform
Fourbeard Rockling	*Enchelyopus cimbrius*	Gadiform
Cusk	*Brosme brosme*	Gadiform
Threebeard Rockling	*Gaidropsarus vulgaris*	Gadiform
Atlantic Tomcod	*Microgadus tomcod*	Gadiform

To better compare and contrast bay-wide fish abundances to abundance estimates for the JB site, a Jamestown Bridge Fish Abundance Index (JBI_A) was calculated. The JBI_A represents the difference between the fish abundance at a given station from the abundance at the JB site:

$$JBI_A \text{ at station } x = \text{Abundance at station } x - \text{Abundance at JB site}$$

A positive JBI_A indicates the trawl data for the given station displayed greater fish abundance than the JB site; a negative value indicates lower fish abundance. A plot of JBI_A versus station highlights the conclusions drawn from the fish abundance plot: lower bay abundances are moderate and approximately equal to JB abundances; abundances peak in mid bay; and upper bay abundances are generally low and less than JB abundances (figure 3).

Quality fishing experience is dependent not only on the quantity of fish present but also to some degree on the number of different types of fish present. To assess fish diversity throughout the bay, the number of species caught at each trawl station, or the species richness (R), was calculated and compared across all stations. Data were plotted as a Jamestown Bridge Fish Species Richness Index (JBI_R). The JBI_R represents the difference between the fish species richness at a given station from the richness at the JB site:

$$JBI_R \text{ at station } x = \text{Richness at station } x - \text{Richness at JB site}$$

A positive JBI_R indicates the trawl data for the given station displayed a greater number of fish species relative to the JB site; a negative value indicates the trawl data for the given station displayed a lower number of fish species relative to the JB site. The JBI_R indicated that the JB site had the highest species richness (70 species), and richness decreased fairly regularly up-bay to a minimum (44 species) at stations 13.2 and 26 (figure 4).

To more finely assess spatial and temporal variations in potential quality of fishing, abundance data were pooled for specified groups of species (see table 2) and evaluated on a seasonal basis (figure 5). Monthly data were assigned to seasons based on qualitative observations of major shifts in various species abundances, yielding the following bins: Winter (December, January, February, March), Spring (April, May), Summer (June, July, August, September), and Fall (October, November). Species groups evaluated for seasonal abundance patterns included (a) important, high value, recreational species (important), (b) herring-like species belonging to the Order Clupeiformes and Atheriniformes (clupeiform), (c) flatfish species belonging to the Order Pleuronectiformes (pleuronectiform), and (d) the cod-like species belonging to the Order Gadiformes (gadiform).

Seasonal bay fish abundance data for all species combined (figure 5a) indicated that summer and fall months dominated the total abundance (on average, 85% of fish were caught between June and October). The bay-wide summer abundance pattern for all species was similar to that for total abundance: maximum values in mid bay, moderate values in the lower bay, and generally decreased abundances in the upper bay. In the fall however, there appeared to be a shift in abundance up-bay: while the mid bay still displayed maximum abundance in the fall (1047 fish/tow averaged across all five mid bay stations) lower bay stations had lowest abundances (252 fish/tow averaged across two lower bay stations) and upper bay stations had moderate

abundances (481 fish/tow averaged across the five upper bay stations). Winter and spring abundances of all species combined were generally low throughout the bay but again displayed maxima in the mid bay region.

Similar to all species combined, the important recreational species group were most abundant in mid bay regions, moderate in the lower bay, and least abundant in the upper bay (figure 5b). Important species abundance was also strongly seasonal with summer months (June-September) accounting for 81% of total abundance, and fall months (October-November) an additional 12%. Important species abundance in the winter months was extremely low (less than 1% of important species were caught between December and March).

Although not typically important recreational fish, seasonal abundances of clupeiform species were evaluated as these fish are often prey species for other important migratory fish such as bluefish, striped bass, and weakfish (figure 5c). As with all species combined and important species, clupeiforms were most abundant during summer and fall months (79% of total abundance). Clupeiform data also displayed a strong maximum abundance in the mid bay region (stations 138 and 89 particularly). Unlike the previous seasonal analyses however, clupeiforms tended to be of similar abundance or greater in the upper bay compared to the lower bay throughout spring, summer, and fall months.

Spatial and temporal variations for both the pleuronectiforms and gadiforms were similar to one another, with generally less patterned variation across stations and seasons compared to the other species groups (figures 5d and e). Abundances were much more evenly distributed throughout the seasons with spring showing a small maximum of 36% and 44% of total abundance for pleuronectiforms and gadiforms, respectively. All other seasons contributed a minimum of 15% towards total abundance. Spatial variation across the bay was mixed with no geographic region displaying any clear dominance. Rather, the data suggest abundances of both of these groups are site specific and perhaps reflect distinct habitat preferences. It should also be noted that abundances for these two groups were one to two orders of magnitude less than the important or clupeiform species groups.

Abundances of important high value recreational fish species were further evaluated on a monthly basis (figure 6). Bluefish, striped bass and weakfish were represented in the trawl data from April through November, but clearly peaked in numbers in August and September (figure 6a). Spatially, these three seasonal migrant species appeared to be distributed throughout the three geographic regions of the bay but displayed higher abundances in the mid and upper regions during the summer months. Winter and summer flounder monthly abundances were much more evenly distributed both spatially and temporally (figure 6b). Winter flounder were present throughout the year, with a modest abundance peak in the spring. Winter and summer flounder were also well represented throughout all three geographic regions with slightly higher numbers suggested in the upper bay. Tautog and black sea bass were also present throughout the year but in very small numbers (on average < 5 per tow). These small numbers make general conclusions on spatial and temporal variations difficult, but numbers do appear to show a broad peak from late spring through fall (figure 6c). Scup and squid are also seasonally migratory species in the bay and both displayed peak abundances in late summer and early fall (figure 6d

and 6e). Scup appeared to be more widely distributed geographically, with good representation throughout the bay. In contrast, squid were more concentrated in mid and upper bay stations.

The spatial and temporal fish abundance patterns discussed above suggest several general conclusions regarding potential quality of recreational fishing throughout the bay. Spatially, mid bay locations appear to offer the best fishing opportunities. This region generally showed the highest abundances of fish and relatively high species richness. Lower bay stations typically displayed somewhat more moderate abundances but did have high species richness. Upper bay stations would appear to offer the least valuable fishing experience with generally lower abundances and richness. Temporally, summer and fall months would appear to offer the best fishing opportunities, particularly for recreationally important species. This strong seasonality is not surprising given that many of the important species are seasonal migrants in the bay (e.g. bluefish, striped bass, weakfish, scup, squid). Year-round resident bay species displayed less seasonal variation but tended to be of lower abundance overall (e.g. winter flounder, tautog, black sea bass). Spatial distribution of these resident species also appeared to be more site-specific with no clear preference for the lower, mid, or upper bay.

As discussed previously, using trawl data to draw conclusions about distribution patterns of important recreational fish is difficult due to potential limitations with the dataset. Most notably, several of the important recreational species may be under sampled in the trawl surveys and thus result in low abundance estimates. For example, migratory predators such as bluefish, striped bass, and weakfish are likely under-represented in the trawl data because these species are too large, and swim too quickly to be captured efficiently by the trawl gear employed in the RIDEM survey. Additionally, due to the tendency of these fish to congregate in dense feeding schools, the concentration of these species is typically highly mobile and patchy. Generalized estimates of regional abundances are therefore difficult to estimate for these species.

The abundance of clupeiforms, an important group of prey species, may serve as an indicator for potential migratory predator species abundances. Bluefish, striped bass and weakfish are voracious predators and will often be found following schools of prey species, such as clupeiforms. Abundant clupeiforms may therefore suggest the potential for attracting the high quality predatory fish many recreational anglers are interested in. As discussed, clupeiform abundance was highly seasonal with an extended peak through the summer and fall months. While maximum abundances of these species were found in mid bay locations, upper bay stations displayed moderately high abundances as well. This would suggest that mid and upper bay regions may attract higher abundances of bluefish, striped bass, and weakfish over a more extended period of time than the trawl data indicated for these species.

Wider distribution, both spatially and temporally, of migratory predator species is also suggested from the RIDEM *2005 online recreational fishing survey*. While this is qualitative data, it does provide ancillary evidence for bay wide patterns in fishing effort and indirectly fish abundance patterns. Results from the survey suggested that bluefish and striped bass were consistently the most sought after fish by recreational anglers throughout the bay (see Appendix A for survey data). Peak fishing effort for these two species occurred in summer months but extended from March through November. The survey data corroborates the conclusion from the monthly abundance analysis that abundance of these species likely peaks in summer but presence in the

bay extends from spring through fall. The survey data also indicated strong fishing effort on bluefish and striped bass throughout most of the bay thus supporting the theory that these predator species are more widely distributed then the trawl data implied.

Additional anecdotal information from a variety of fishing websites also implies a wide temporal and spatial distribution of quality fishing opportunities in the bay for bluefish and striped bass. Information on these sites indicated presence of blues and stripers in the bay from mid April through November with peak abundances in late summer and early fall. Quality fishing in regions of the bay which were not adequately sampled in the trawl survey (i.e. Providence, Seekonk, and Palmer Rivers and Greenwich Bay) all support quality fishing opportunities, particularly later in the season according to a variety of websites.

Data from the online survey also supports the general conclusion that species richness and diversity increase in mid and lower bay regions. In upper bay sites, the survey indicated fishing effort was almost exclusively on bluefish and striped bass. Fishing effort diversity appeared to increase down bay with greatest diversity in the lower east and west passages (in the vicinity of North Kingstown, Jamestown, and Newport).

Summary:

As previously stated, the RIDEM trawl data is an excellent quantitative dataset but its geographic limitations and poor sampling of large, fast swimming predatory species make conclusions regarding the quality of recreational fishing opportunities at specific alternative fishing access sites challenging. Grouping the alternative sites into general geographic regions of lower, mid and upper bay allow for some general recommendations. Online survey data and anecdotal information, while qualitative, provide additional supporting information. In general, all of the proposed fishing access sites would appear to offer at least good recreational fishing opportunities. The following general conclusions offer some more specific rankings of the proposed sites:

1. Lower and mid bay sites would appear to offer the highest quality recreational fishing potential. Both fish abundance and diversity are high in these regions and existing fishing effort is high. Access sites in this group include the old Jamestown Bridge site and the following alternative sites:

9) Stone Bridge
10) Carr Point
11) Burma Road
13) Van Zandt Pier
14) Fort Adams
15) Fort Getty
16) Hull Cove
17) Fort Wetherill
18) Rome Point
19) QPD Allen's Harbor
22) Bay Campus

2. Access sites at the mouth of the bay, while displaying high diversity, would appear to have somewhat lower abundances and somewhat reduced fishing effort relative to mid bay sites. While potentially offering good quality fishing opportunities, these sites are ranked slightly below those listed above and include:

8) Sakonnet Point
12) Brenton Point

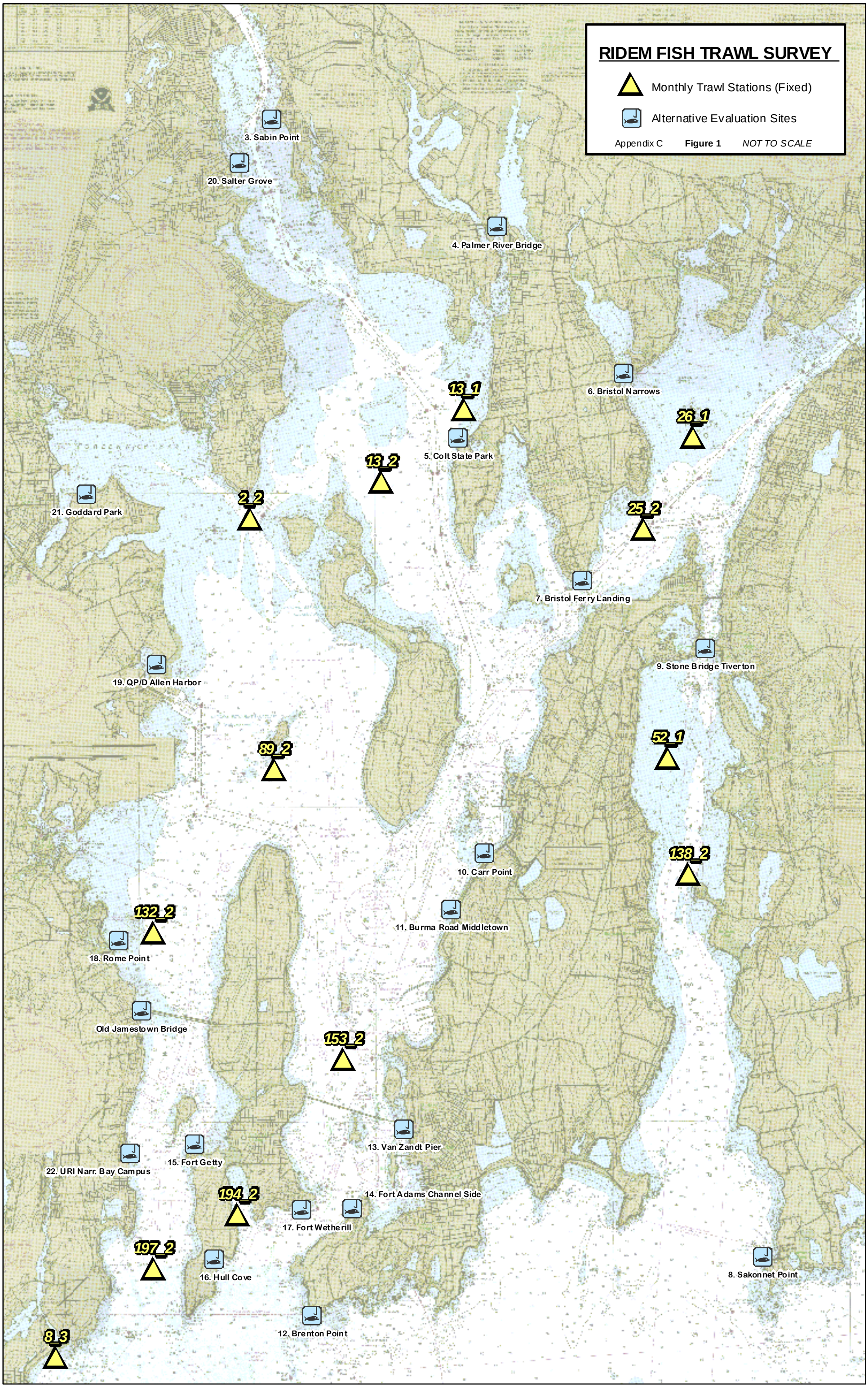
3. Upper bay sites appear to provide less diversity and lower abundances of fish relative to mid bay and lower bay sites. Clupeid abundances and strong fishing effort in these regions suggest that good opportunities do exist for bluefish and striped bass however. These stations include:

4) Palmer River Bridge
5) Colt State Park
6) Bristol Narrows
7) Bristol Ferry Landing

4. Seekonk and Providence River sites, as well as the Greenwich Bay site were difficult to assess as these areas were considered somewhat different oceanographically from regions represented by the trawl stations. Most notably, all of these regions exhibit extensive periods of hypoxia (low dissolved oxygen) during summer months which would likely reduce both fish abundance and diversity during these times. However, when dissolved oxygen concentrations are sufficient these sites likely support good opportunities for quality fishing. Greenwich Bay would likely be ranked similar to the mid bay stations with high quality opportunities. The Providence and Seekonk River stations would likely be more similar to the upper bay stations with less diverse but good opportunities for bluefish and striped bass. Thus the following five sites, while offering good fishing opportunities, are likely limited particularly in summer months (when fishing effort is highest). Therefore the following sites are assigned a qualitative ranking of seasonally good opportunities:

1) State Pier #2
2) Gano Street
3) Sabin Point
20) Salter Grove
21) Goddard Park

Appendix C Figures


RIDEM FISH TRAWL SURVEY
Monthly Trawl Stations (Fixed)
Alternative Evaluation Sites
Appendix C
Figure 1
NOT TO SCALE
3. Sabin Point
20. Salter Grove
4. Palmer River Bridge
6. Bristol Narrows
13_1
5. Colt State Park
26_1
13_2
21. Goddard Park
2_2
25_2
7. Bristol Ferry Landing
9. Stone Bridge Tiverton
19. QP/D Allen Harbor
89_2
52_1
10. Carr Point
138_2
132_2
11. Burma Road Middletown
18. Rome Point
Old Jamestown Bridge
153_2
13. Van Zandt Pier
15. Fort Getty
22. URI Narr. Bay Campus
194_2
14. Fort Adams Channel Side
17. Fort Wetherill
197_2
16. Hull Cove
8. Sakonnet Point
12. Brenton Point
8_3

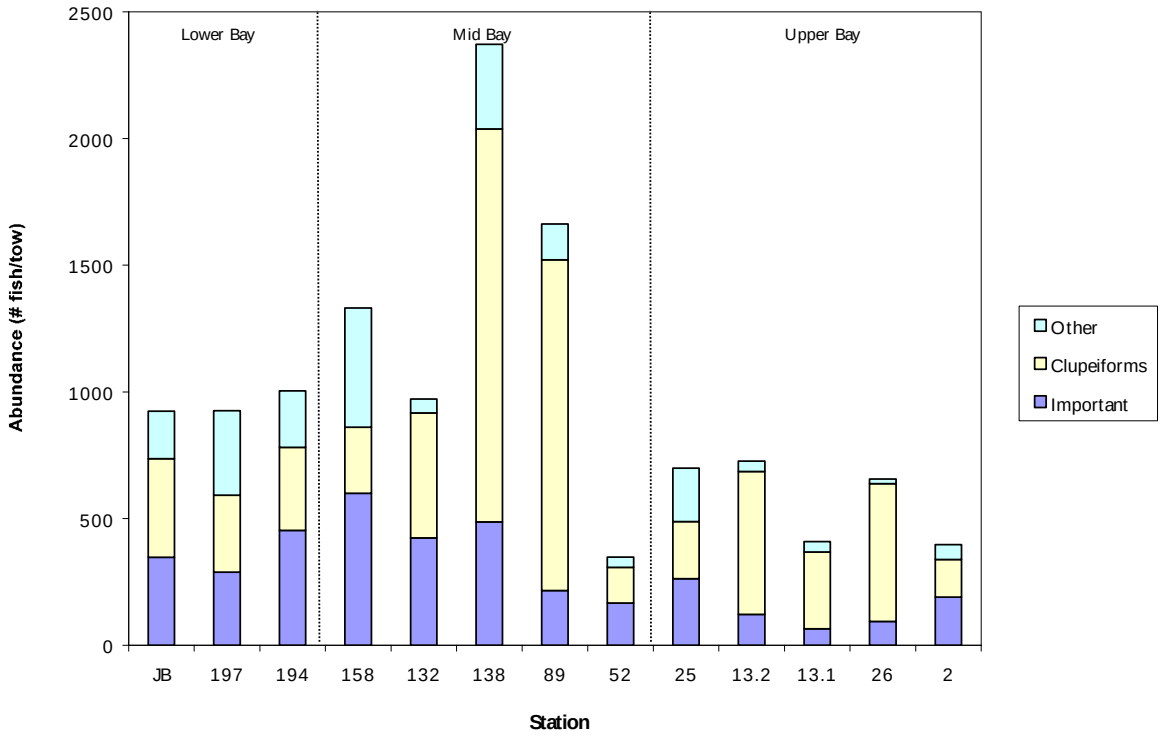


Figure 2. Mean Bay Fish Abundance by Station.

Values are plotted as the mean number of fish per tow. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values estimated for the old Jamestown Bridge site based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines. Total fish abundance has been subdivided into three species groups: recreational 'important' species, 'clupeiform' species, and all 'other' remaining species (see text for details on species group descriptions).

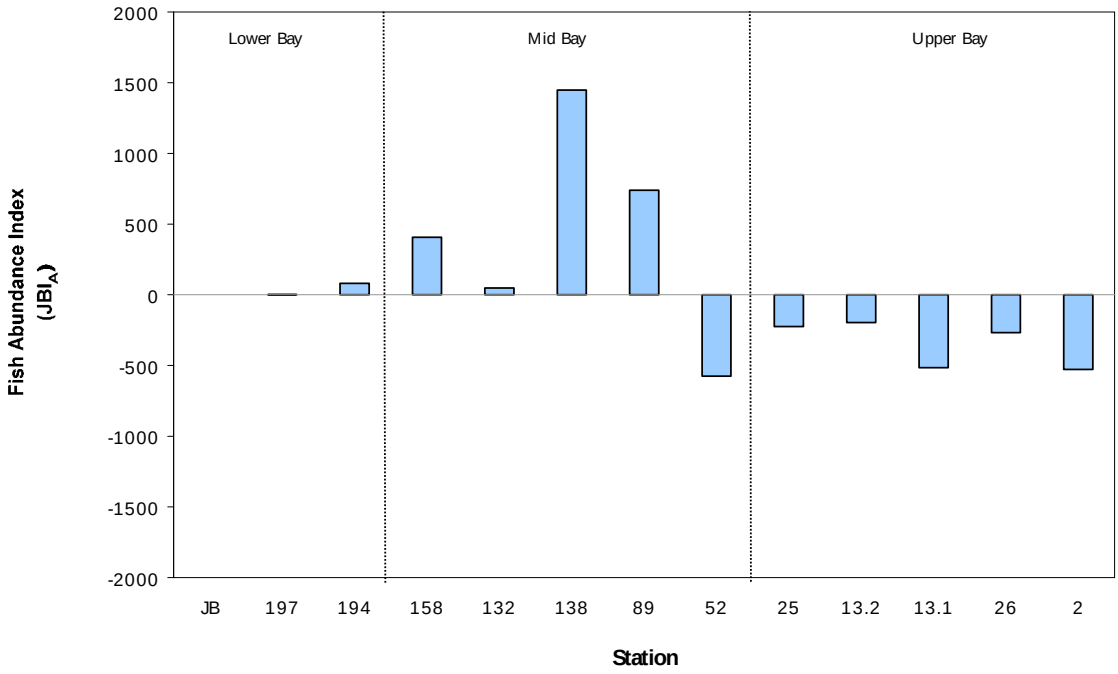


Figure 3. Jamestown Bridge Fish Abundance Index (JBI_A).

Plotted values represent the difference in mean number of fish per tow at each RIDEM trawl station relative to estimated Jamestown Bridge abundances. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values estimated for the old Jamestown Bridge location based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines.

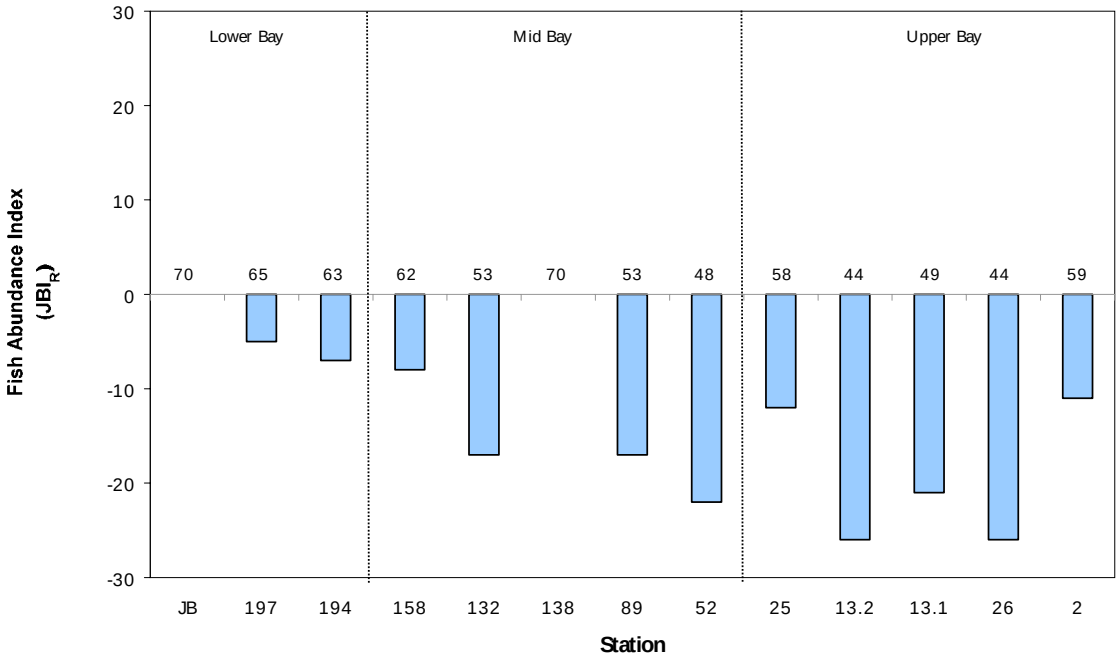


Figure 4. Jamestown Bridge Fish Species Richness Index (JBI_R).

Plotted values represent the difference in total number of fish species represented at each RIDEM trawl station relative to calculated number at the old Jamestown Bridge. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values calculated for the old Jamestown Bridge location based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines. The number at the top of each column represents the total number of species caught at the given station.

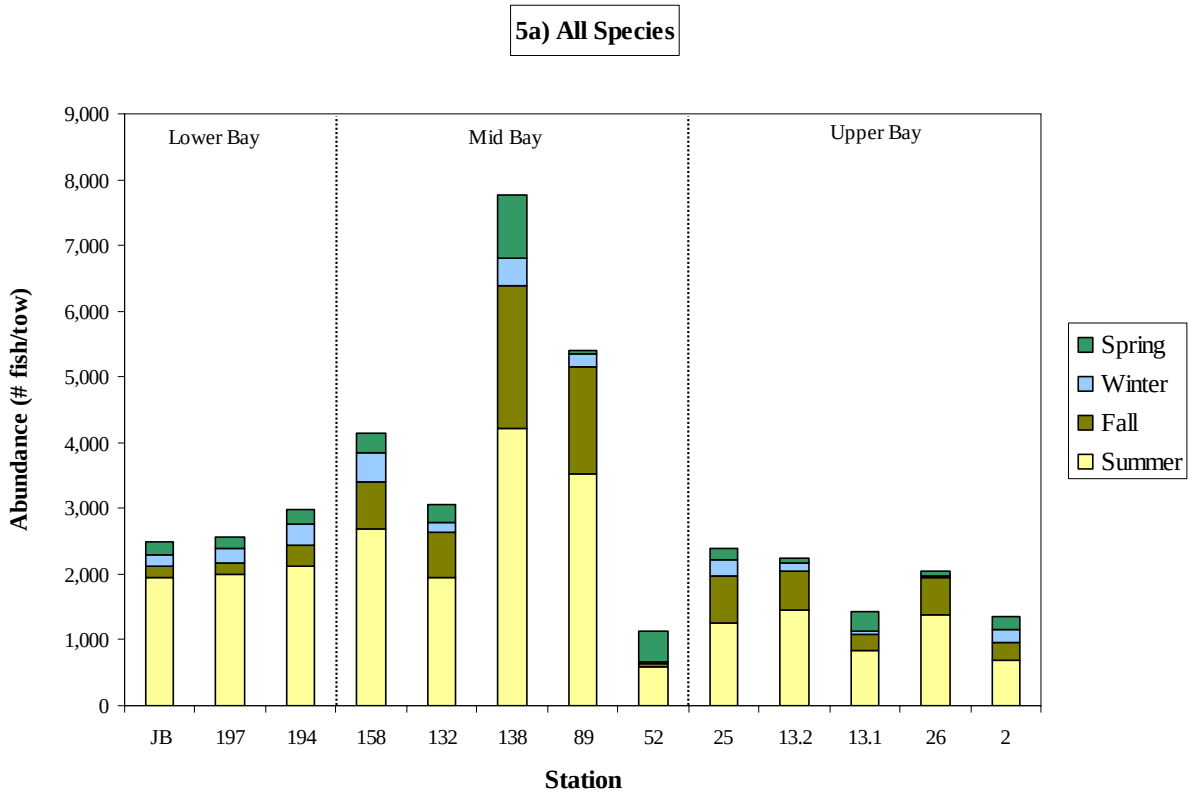


Figure 5a. Seasonal Bay Fish Abundances: All Species.

Values are plotted as the mean number of fish per tow. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values estimated for the old Jamestown Bridge location based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines. Total fish abundances have been subdivided seasonally as summer (June-September), Fall (October-November), Winter (December-March) and Spring (April-May).

Note: variable y-axis between graphs

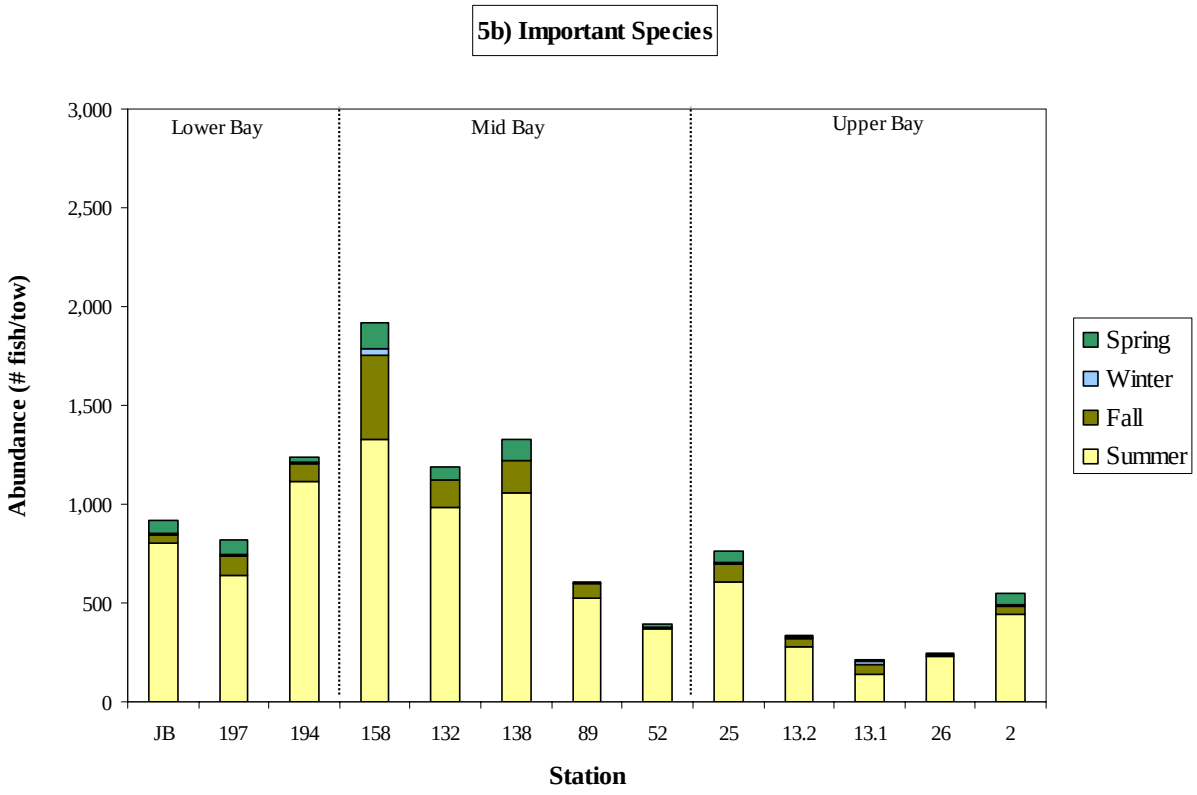


Figure 5b. Seasonal Bay Fish Abundance: Important Species.

Values are plotted as the mean number of fish per tow for recreational important species (Summer Flounder, Winter Flounder, Bluefish, Striped Bass, Black Sea Bass, Tautog, Scup, Weakfish, Longfin and Shortfin Squid). Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values estimated for the old Jamestown Bridge location based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines. Total fish abundances have been subdivided seasonally as summer (June-September), Fall (October-November), Winter (December-March) and Spring (April-May).

Note: variable y-axis between graphs

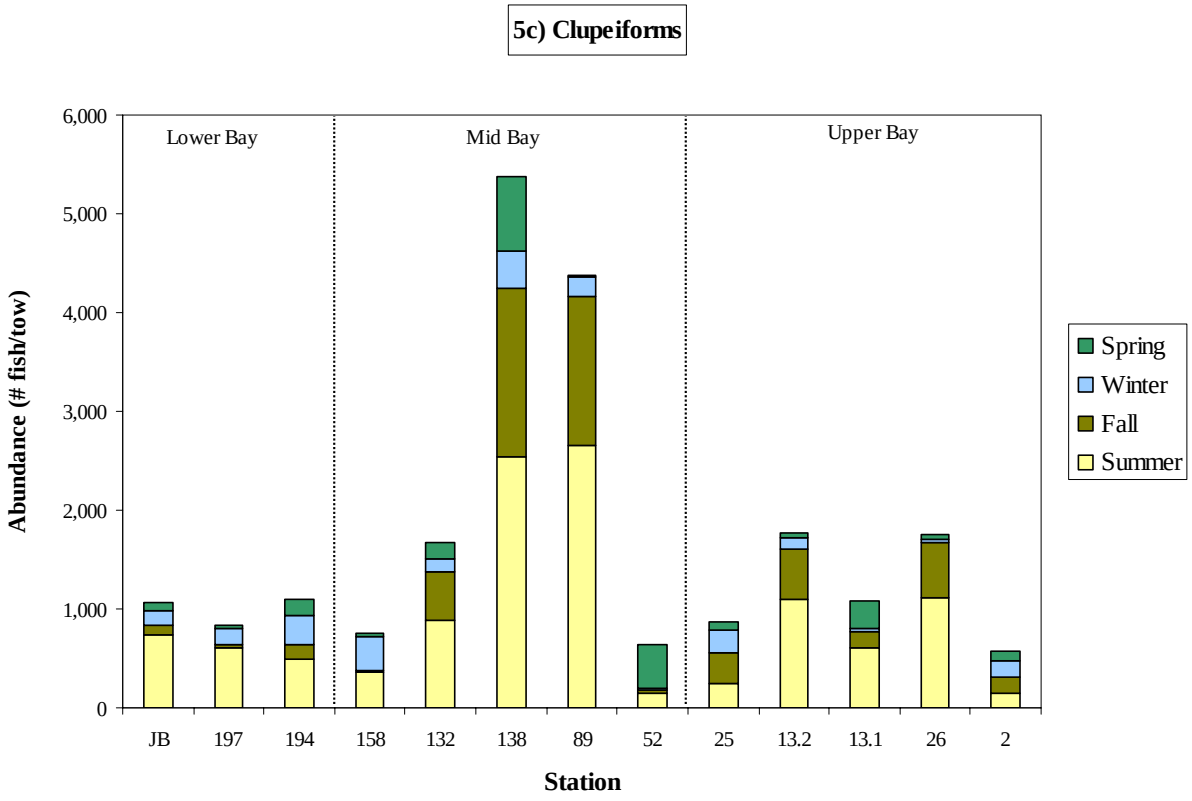


Figure 5c. Seasonal Bay Fish Abundance: Clupeiform Species.

Values are plotted as the mean number of fish per tow for clupeiform species (Round Herring, Atlantic Herring, Alewife, Blueback Herring, American Shad, Atlantic Menhaden, Hickory Shad, Bay Anchovy, Striped Anchovy, Atlantic Silverside). Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values estimated for the old Jamestown Bridge location based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines. Total fish abundances have been subdivided seasonally as summer (June-September), Fall (October-November), Winter (December-March) and Spring (April-May).

Note: variable y-axis between graphs

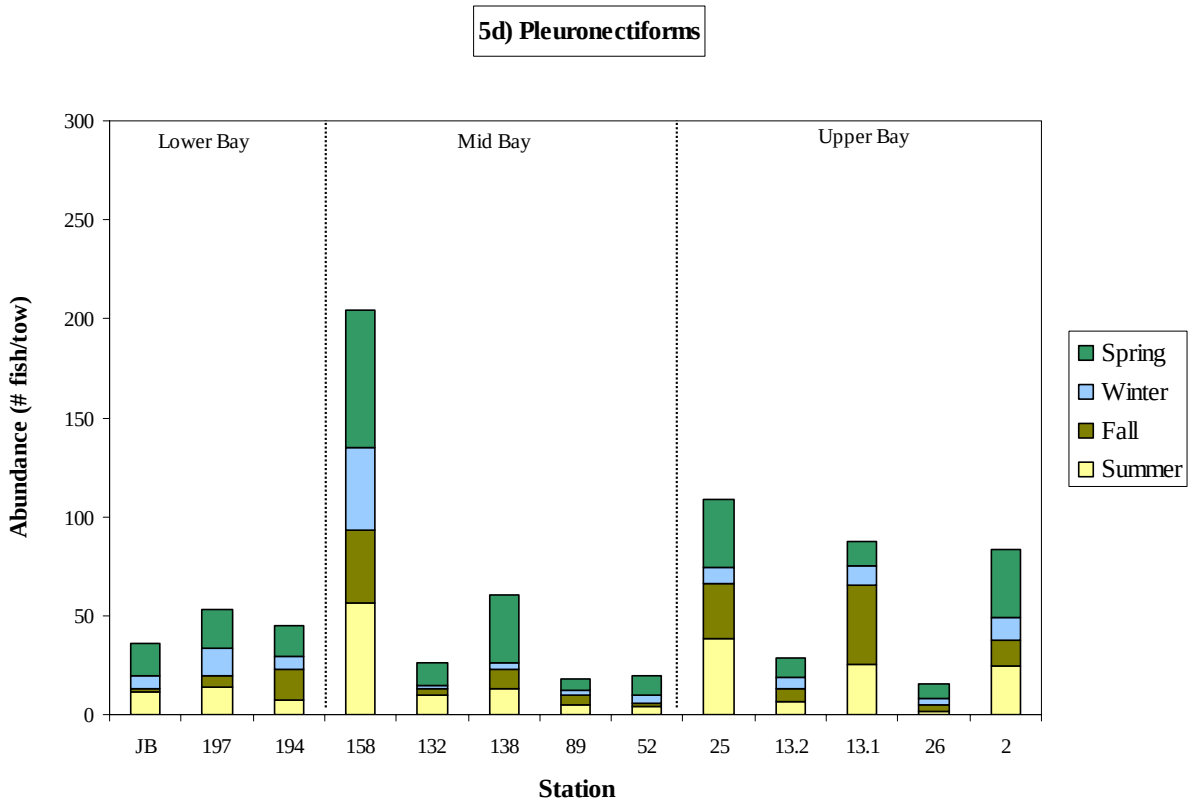


Figure 5d. Seasonal Bay Fish Abundance: Pleuronectiform Species.

Values are plotted as the mean number of fish per tow for pleuronectiform species (Summer Flounder, Fourspot Flounder, Yellowtail Flounder, Winter Flounder, Windowpane, Gulfstream Flounder, Smallmouth Flounder, Hogchoker). Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values estimated for the old Jamestown Bridge location based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines. Total fish abundances have been subdivided seasonally as summer (June-September), Fall (October-November), Winter (December-March) and Spring (April-May).

Note: variable y-axis between graphs

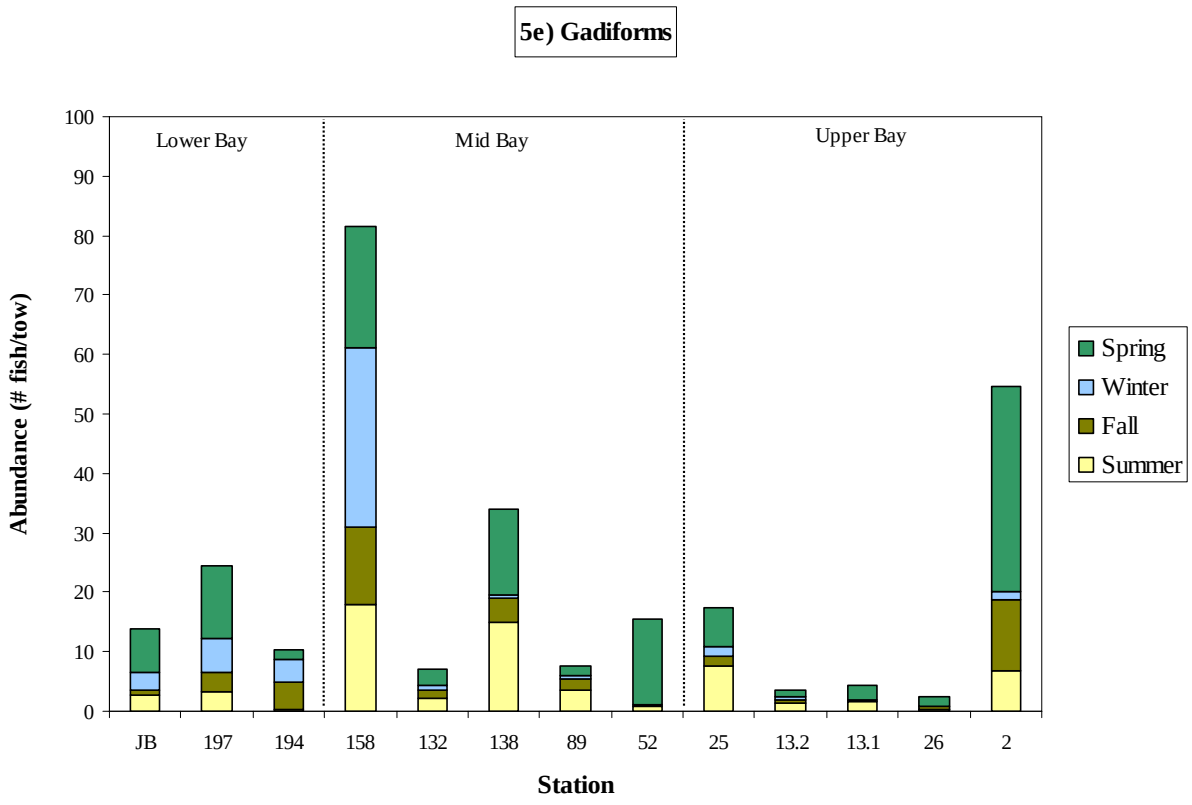


Figure 5e. Seasonal Bay Fish Abundance: Gadiform Species.

Values are plotted as the mean number of fish per tow for gadiform species (Silver Hake, Atlantic Cod, Haddock, Pollock, White Hake, Red Hake, Spotted Hake, Fourbeard Rockling, Cusk, Threebeard Rockling, Atlantic Tomcod). Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. "JB" data represent values estimated for the old Jamestown Bridge location based on previous analyses (see text). Stations are arranged as a bay transect; with "lower", "mid", and "upper" bay stations separated by the dashed lines. Total fish abundances have been subdivided seasonally as summer (June-September), Fall (October-November), Winter (December-March) and Spring (April-May).

Note: variable y-axis between graphs

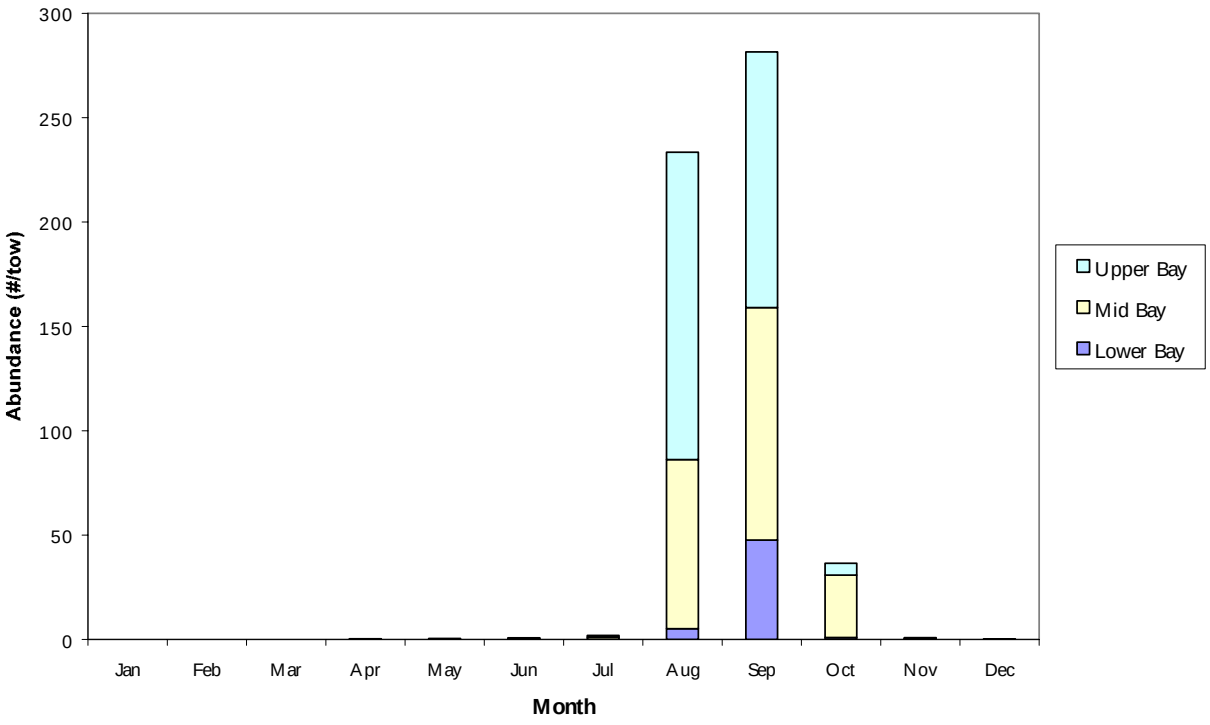


Figure 6a. Monthly Bay Abundance of Important Recreational Fish: Bluefish, Striped Bass, and Weakfish.

Values are plotted as the mean number of fish per tow by month. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. Total abundance has been subdivided geographically as lower (stations 197, 194), mid (stations 158, 132, 138, 89, 52), and upper (25, 13.1, 13.2, 26, 2) bay stations.

Note: variable y-axis between graphs

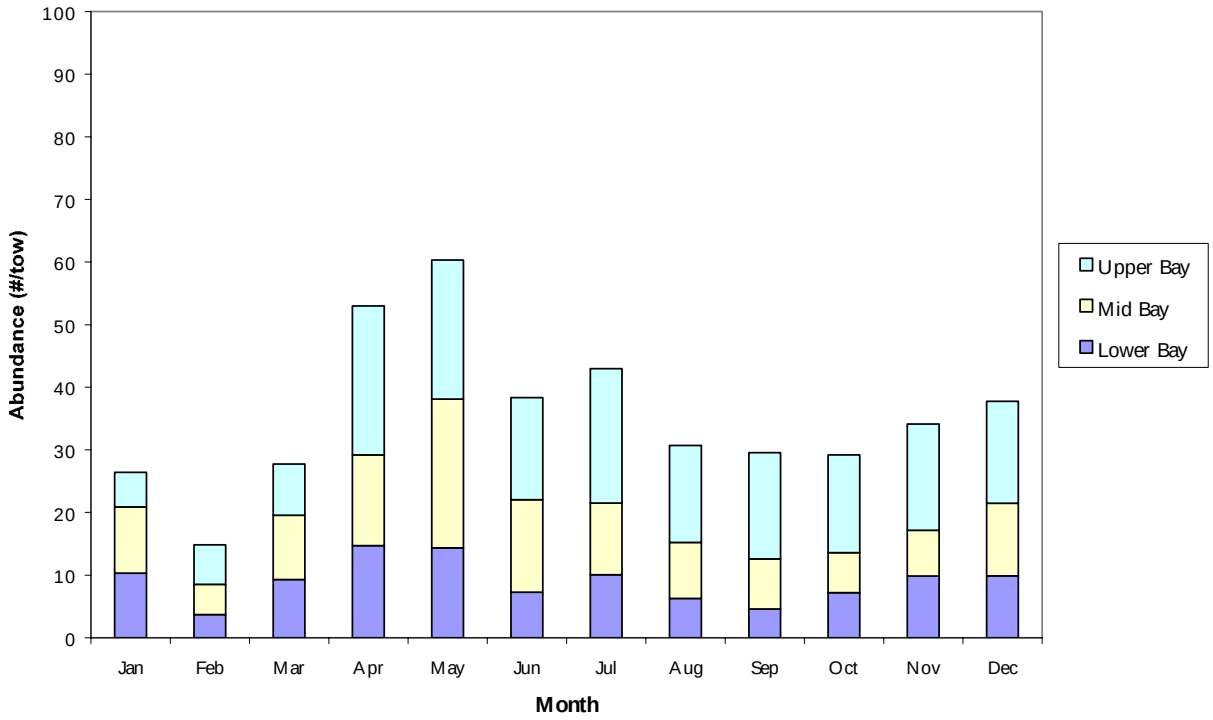


Figure 6b. Monthly Bay Abundance of Important Recreational Fish: Winter and Summer Flounder.

Values are plotted as the mean number of fish per tow by month. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. Total abundance has been subdivided geographically as lower (stations 197, 194), mid (stations 158, 132, 138, 89, 52), and upper (25, 13.1, 13.2, 26, 2) bay stations.

Note: variable y-axis between graphs

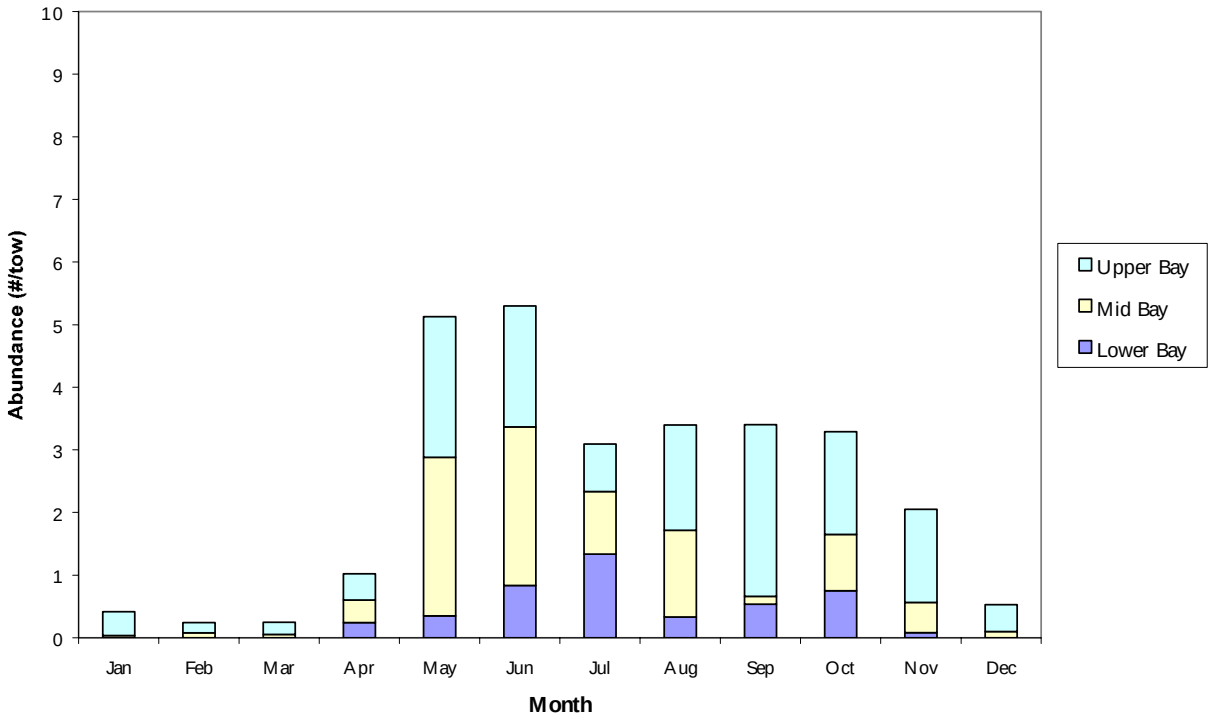


Figure 6c. Monthly Bay Abundance of Important Recreational Fish: Tautog and Black Sea Bass.

Values are plotted as the mean number of fish per tow by month. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. Total abundance has been subdivided geographically as lower (stations 197, 194), mid (stations 158, 132, 138, 89, 52), and upper (25, 13.1, 13.2, 26, 2) bay stations.

Note: variable y-axis between graphs

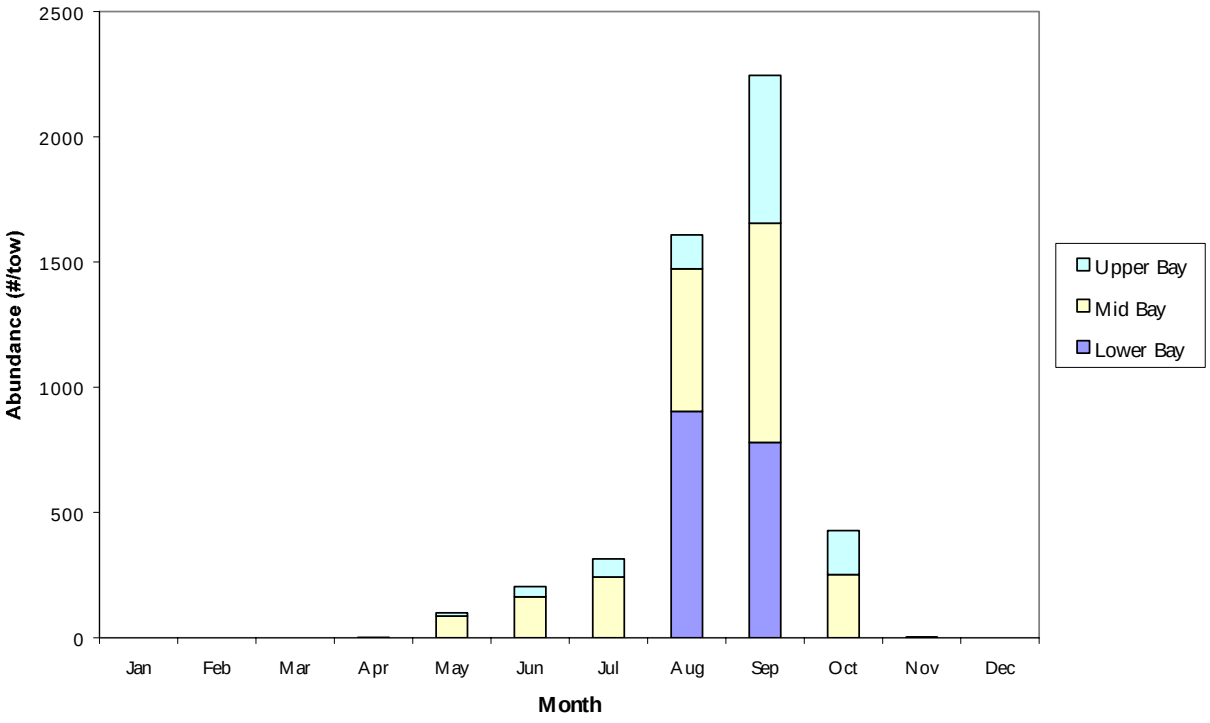


Figure 6d. Monthly Bay Abundance of Important Recreational Fish: Scup.

Values are plotted as the mean number of fish per tow by month. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. Total abundance has been subdivided geographically as lower (stations 197, 194), mid (stations 158, 132, 138, 89, 52), and upper (25, 13.1, 13.2, 26, 2) bay stations.

Note: variable y-axis between graphs

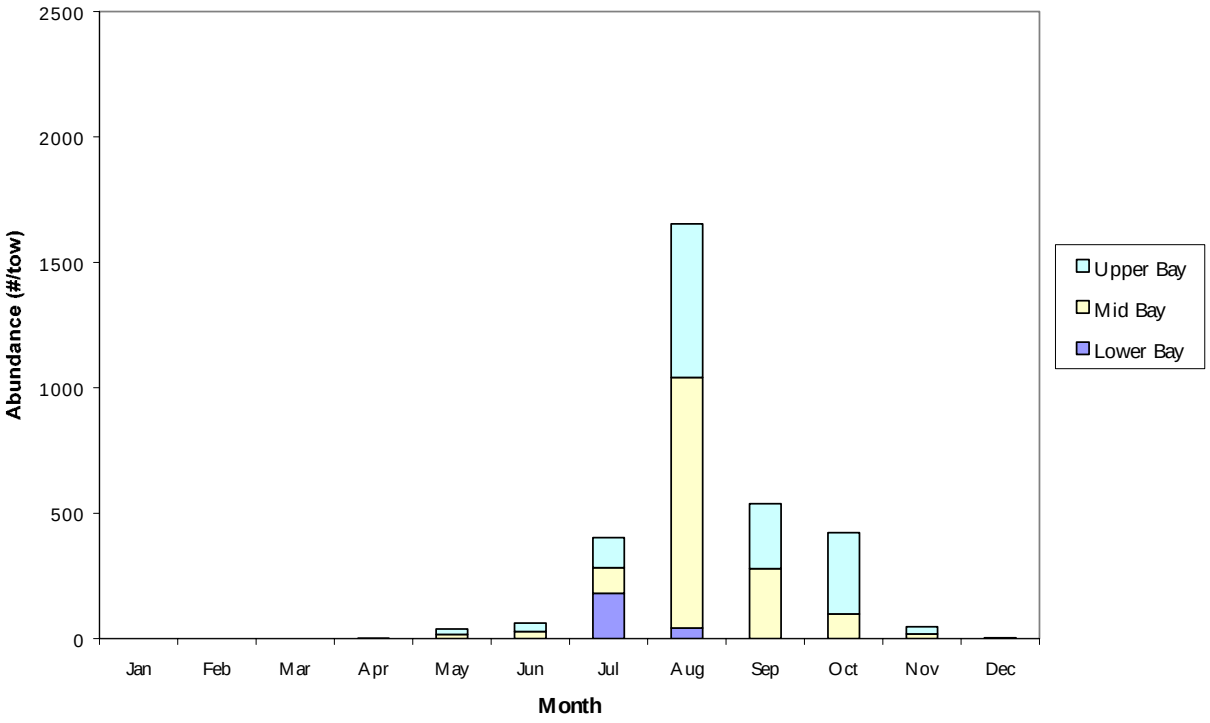


Figure 6e. Monthly Bay Abundance of Important Recreational Fish: Longfin and Shortfin Squid.

Values are plotted as the mean number of fish per tow by month. Data are from twelve RIDEM fish trawl stations collected from 1990 to 2004. Total abundance has been subdivided geographically as lower (stations 197, 194), mid (stations 158, 132, 138, 89, 52), and upper (25, 13.1, 13.2, 26, 2) bay stations.

Note: variable y-axis between graphs